Smart Wastewater Management
- Policy Aspects in Korea -

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KEI
Thanks to many researchers who provided the materials in this presentation.

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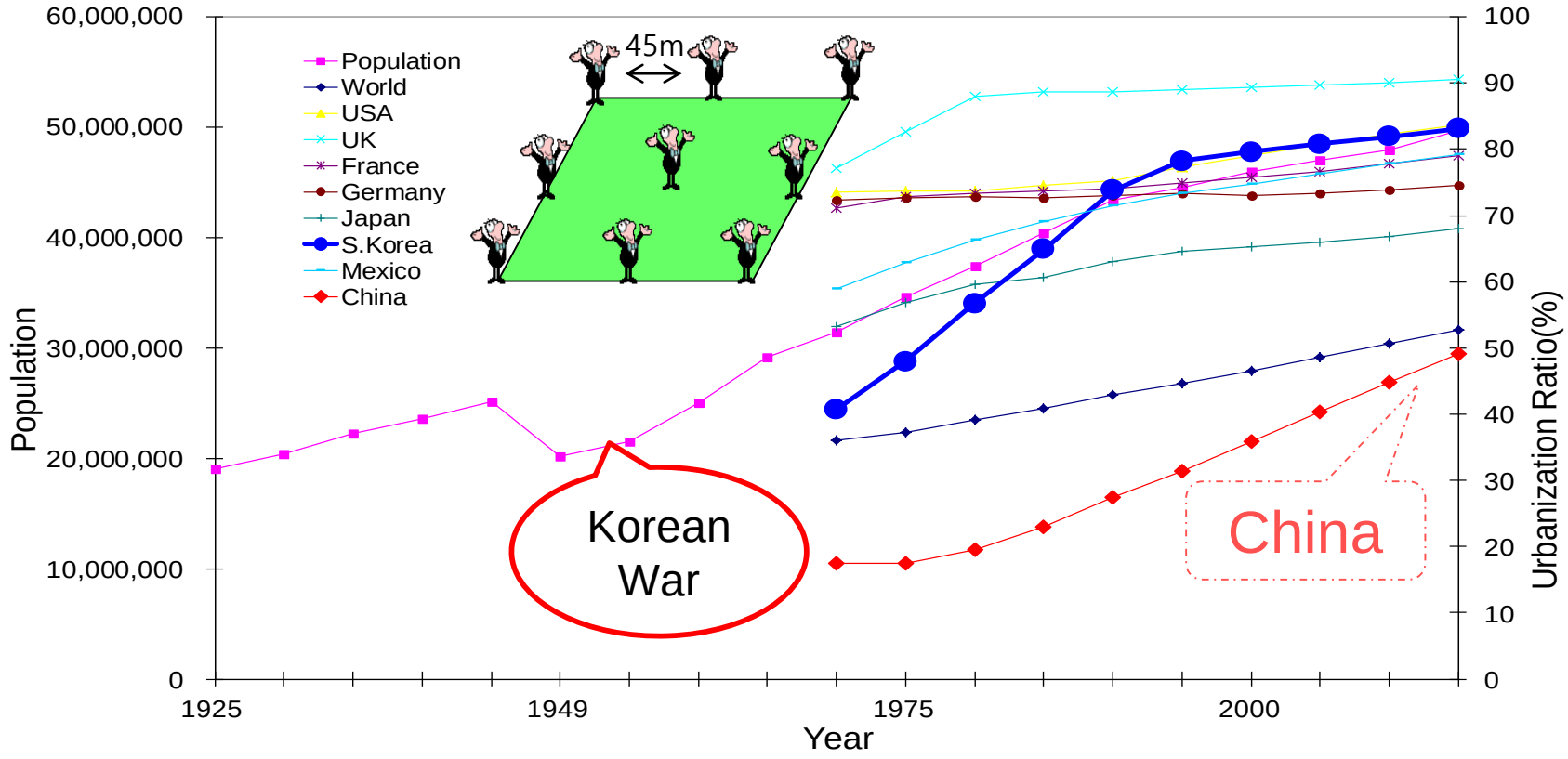
<Education Background>
- KAIST, Ph.D, MS, Civil & Environmental Engineering
- Seoul National University, BS, Agricultural Engineering

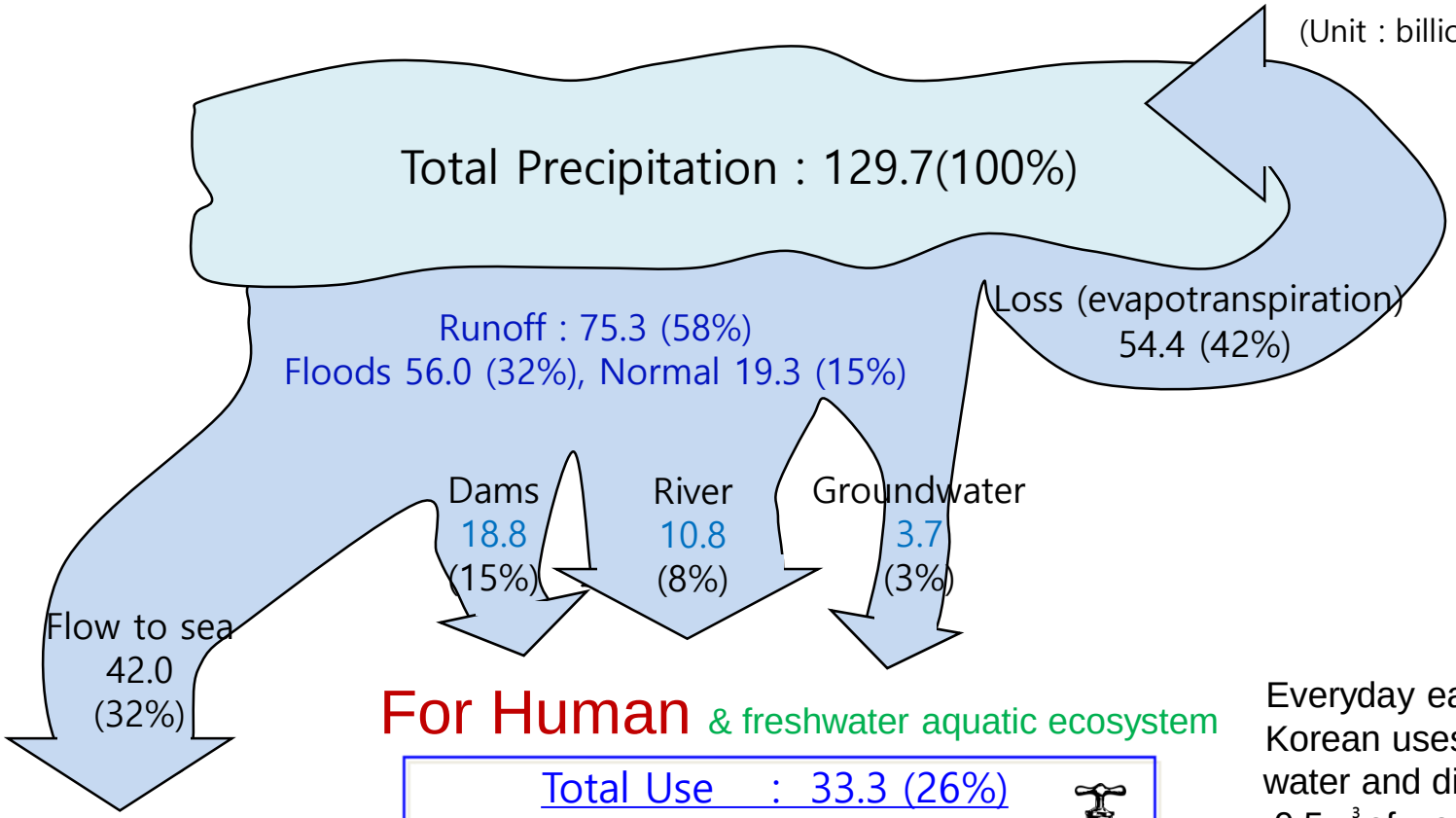
<Research>
- KEI, Water Environment Plan, National Sewerage Plan, TMDL
- KEI, Climate Change Adaptation
- RIST, Automatic Control of WWTP, Life Cycle Assessment
- KICT, Water Quality Modeling, Long-term Water Planning

High Pressures to Water by P, U, I, A

- High population density (Area = 99,000 km^2, P density = 516 capita / km^2)
- Rapid urbanization
- Pressures from industrialization, intensive agriculture and livestock



Water Budget of Korea – High Water Stress



For Human & freshwater aquatic ecosystem

Total Use : 33.3 (26%)
Domestic : 7.5 (5.8%)
Industry : 2.1 (1.6%)
Agriculture : 15.9 (12.3%)
Instream : 7.8 (6.0%)

For Aquatic Ecosystem

Everyday each south Korean uses 1.8 ㎥ of water and discharges 0.5 ㎥ of wastewater.

Footprint is 4.5 ㎥

This exceeds average runoff in land.

Ref. 2nd amendment of 4th Long-term Water Resource Master Plan

Development of Sewerage Laws and Policy Focus

Before 1980

- Before 1960 : deforestation and soil erosion
  - The natural environment was destroyed by resource exploitation policy during Japanese occupation.
  - Korea war destroyed life and property as well as natural environment.
  - Poor economy did not cause serious environmental pollution.
- 1960 – 1981 : sanitation and public health protection
  - Five-year economic development plan achieved high economic growth.
  - Air, waste, water pollution by industrialization and urbanization caused public health problems.
  - The general public did not recognize the problem of environmental pollution.
    - E. coli contamination increased 150 times from 1963 to 1967.
    - Rapid organic water pollution in large cities caused by poor sanitation.
    - BOD of urban stream JoongRangCheon in Seoul was 375 mg/L in 1974.
    - Chemical accidents occurred in industrial complexes.

Development of Sewerage Laws and Policy Focus

Before 1980

- Policy Focus
  - Defensive and passive policy
  - Protection of public health, sanitation
    - Pollution prevention and the improvement of living environment included in 4th economic development plan in 1977.
    - **Constructed many nightsoil treatment plants by loans.**
    - **First POTW for Seoul was constructed in 1976**.
  - Green belt(1971), tree planting, nature protection movement (1977)
- Legal System
  - **Waste Cleaning Act** (1961-1999)
  - **Water Supply Act** (1961-)
  - **Sewerage Act** (1966-)
  - **Pollution Prevention Act** (1963-1977)
  - Toxic and Hazardous Substance Act (1963-1999)
  - Environment Preservation Act (1977-1999)
- Administration System
  - Environment and Sanitation Department in **Ministry of Health and Society** (1967.4)
  - Sewage Management Department in **Ministry of Construction** (1979)
  - Environment Management Division in Ministry of Health and Society (1977)

GDP/capita : 279$ (1970) → 406$ (1973) → 1051$ (1977) → 1774$ (1979)

Development of Sewerage Laws and Policy Focus

1980s

- Policy Focus
  - Active policy through 'command and control' measurement and low-interest loans and subsidies
  - Preservation of natural environment
  - Protection of human health
  - **First environment plan in 5th Economic Development Plan**
  - Started investment for environmental infrastructure including large POTWs, Industrial complex WWTPs, waste treatment plants and sanitary landfill facilities.
  - SOx, NOx control through fuel regulation for heating facilities, vehicles
- Administration System
  - **Environment Protection Agency** (1980-1990)
  - National Institute of Environmental Research (1978-)
  - Environmental Pollution Preservation Corporation (1983-1987), Environmental Management Corporation (1987-2010)
  - Compound Waste Treatment Corporation (1979-2003)
  - Water supply and sewerage work in **Ministry of Construction**
  - Wildlife protection work in Forestry Agency

KEI

GDP/capita : 1704$ (1980) → 2180$ (1983) → 3511$ (1987) → 4686$ (1988)

Development of Sewerage Laws and Policy Focus

1990s

- Policy Focus
  - Advanced environmental management system based on precautionary and economic instruments
  - Environment policy to cope with International Environmental Agreements
  - Established long-term environment improvement plans
  - Water pollution accidents and polluted streams increased the awareness of environment.
  - Expanded environmental budget and constructed public environmental infrastructures.
    - Environmental Budget (billion KWON) : 56.5 (1989), 117.2 (1990), 271.8 (1991), 1153.6 (1999)
    - **Water supply service (%) : 57% (1981), 87% (1999)**
    - **Sewage treatment (%) : 8% (1981), 70% (1999)**
    - **POTWs (No.) : 5 (1980), 172 (1999)**
    - Changed all landfill site to sanitary landfill and constructed waste treatment facilities including incineration
- Administration System
  - **Ministry of Environment** (1990-) and regional office of environment
  - Korea Environment Institute (1993-)
  - Local water supply and sewerage works moved from Ministry of Construction to Ministry of Environment **(1994)**
  - National Institute of Environmental Research (1978-)
  - Environmental Management Corporation (1987-2010)
  - Korea Resource Recovery and Utilization Corporation (1993-2010)

Development of Sewerage Laws and Policy Focus

1990s

- Legal System
  - **Enacted the Basic Law and a separate laws** were enacted by sector (1990-)
    - **Framework Act on Environmental Policy** (1990-)
    - Clean **Air** Conservation Act (1990-)
    - **Water Quality** Conservation Act (1990-)
    - **Noise** and Vibration Control Act (1990-)
    - **Toxic Chemicals** Control Act (1990-)
    - Environmental **Dispute** Adjustment Act (1990-)
  - Water Supply Act (1961-), Drinking Water Management Act (1995-)
  - Sewerage Act (1963-)
  - Waste Control Act (1986-), Act Relating to Promotion of Resources Saving and Reutilization (1992-), Promotion of Installation of Waste Disposal Facilities and Assistance, Etc. to Adjacent Areas Act (1995-)
  - Act Relating to the Treatment of Sewage, Night soil, and Livestock Wastewater (1996-)
  - Act on the Improvement of Water Quality and Support for Residents of the **Watershed** of the Han River (1999-)

Development of Sewerage Laws and Policy Focus

2000s -

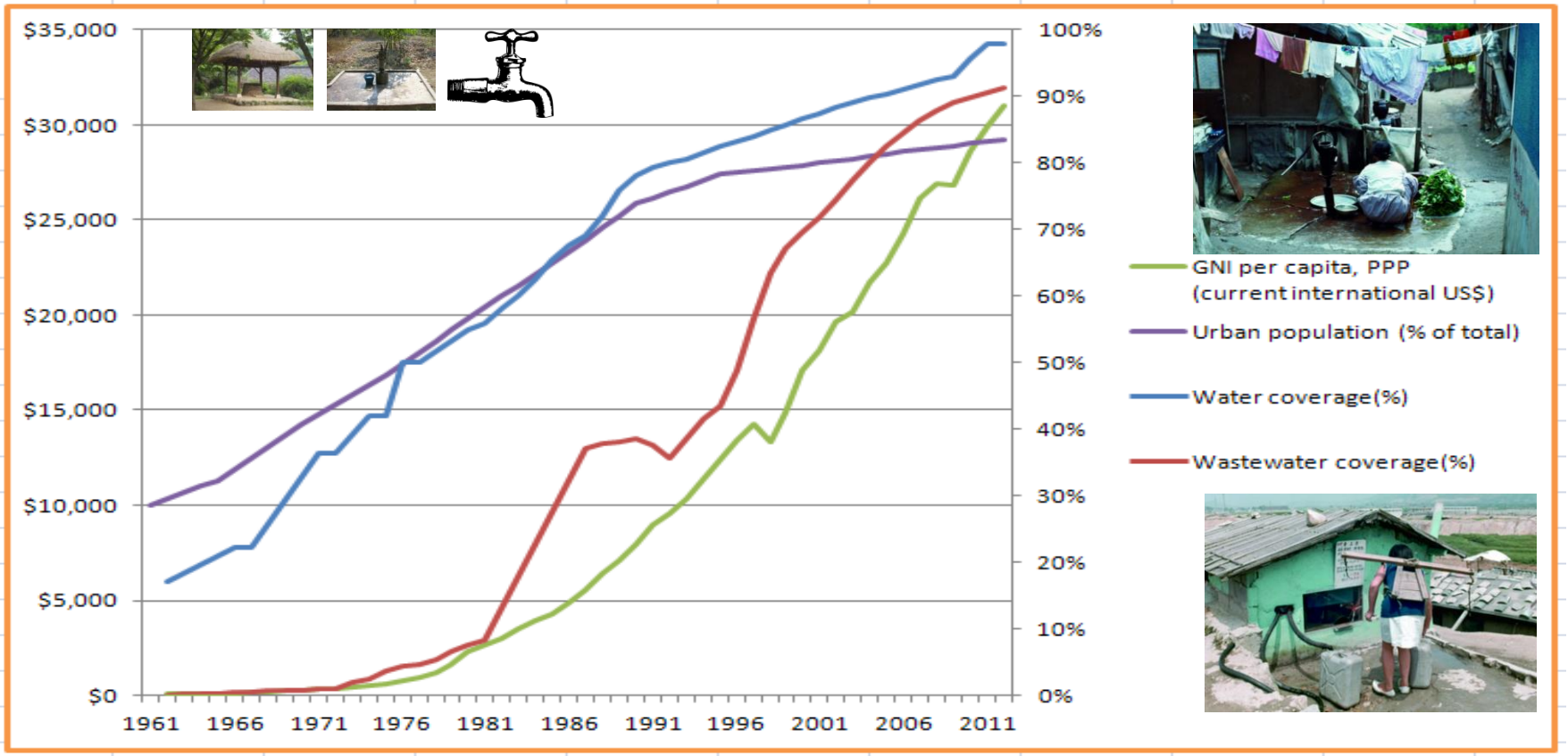
- Policy Focus
  - **Sustainable development**
  - Environment policy in the view of customer
  - Many concerns on personal health
  - Climate change and green growth
- Administration System
  - Ministry of Environment (1990-) and regional office of environment
  - Korean Environment Institute (1993-)
  - National Institute of Environmental Research (1978-)
  - Environmental Management Corporation (1987-2010), Korea Resource Recovery and Utilization Corporation (1993-2010), Korea Environment Corporation (2010-)
  - Sudokwon Landfill Site Operation Corporation (2000-)
  - Korea Environmental Industry and Technology Institute (2001-)
  - National Institute of Biological Resources (2007-)
  - National Institute of Ecology (2013-)

Development of Sewerage Laws and Policy Focus

2000s -

- Legal System
  - Framework Act on Environmental Policy (1990-)
  - Water Quality Conservation Act (1990-2007), Water Quality and Aquatic Ecosystem Conservation Act (2007-)
  - Water Supply Act (1961-), Drinking Water Management Act (1995-)
  - Sewerage Act (1963-)
  - Waste Control Act (1986-), Act Relating to Promotion of Resources Saving and Reutilization (1992-), Promotion of Installation of Waste Disposal Facilities and Assistance, Etc. to Adjacent Areas Act (1995-)
  - Wetland Preservation Act (1999-)
  - Act on the Improvement of Water Quality and Support for Residents of the Watershed of the Han River (1999-)
  - Act on Water Management an Residents Support in the Nakdong River Basin (2002-), Geum River Basin (2002-), Yeongsan and Seomjin River Basins (2002-)
  - Construction Waste **Recycling** Promotion Act (2003-)
  - Act on Resource **Circulation** of Electrical and Electronic Equipment and Vehicles (2007-)
  - Promotion and Support for Water **Reuse** Act (2010-)

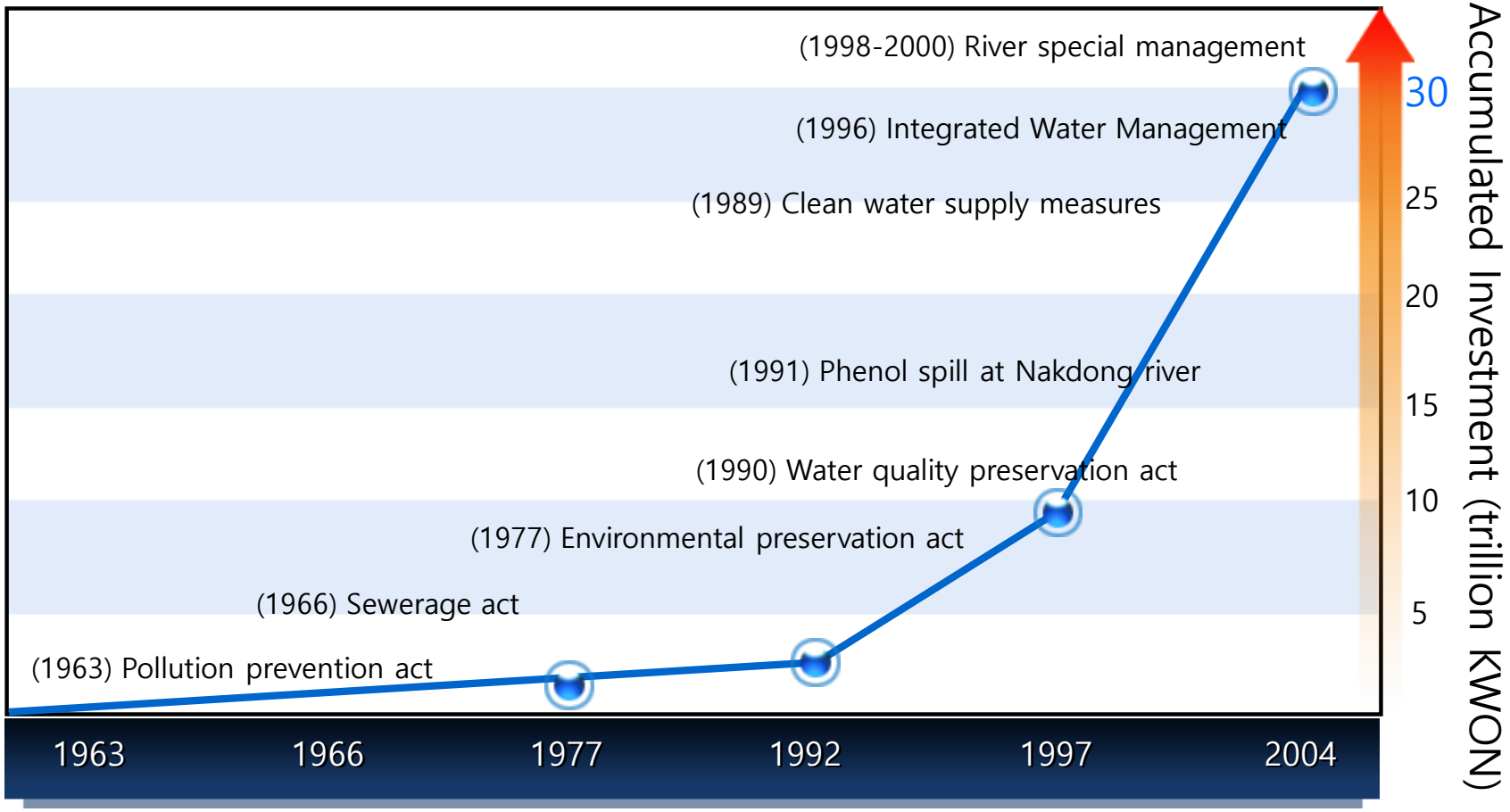
Water Infra Construction – key role for development



	1961		2015
GDP/capita (USD)	85	→	27,105
Drinking Water Supply Service (%)	17%	→	98.8%
Sewerage Service (%)	2%	→	92.9%

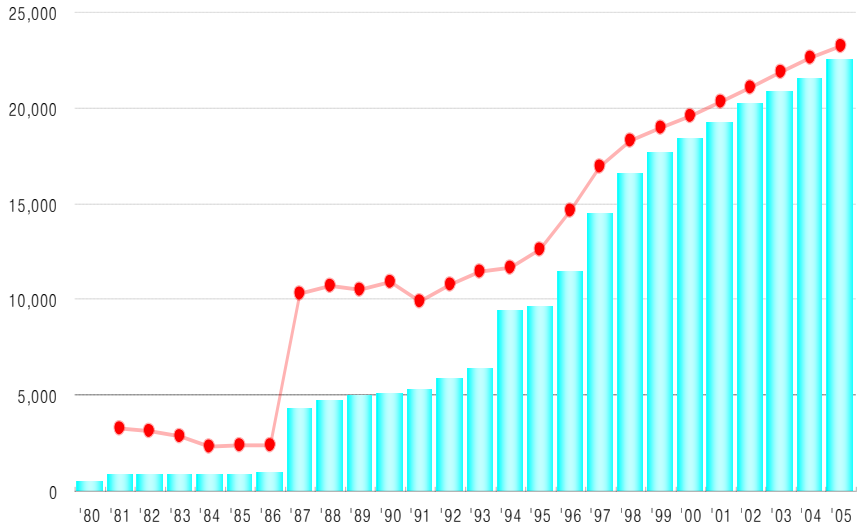
Past History of Water Pollution Control

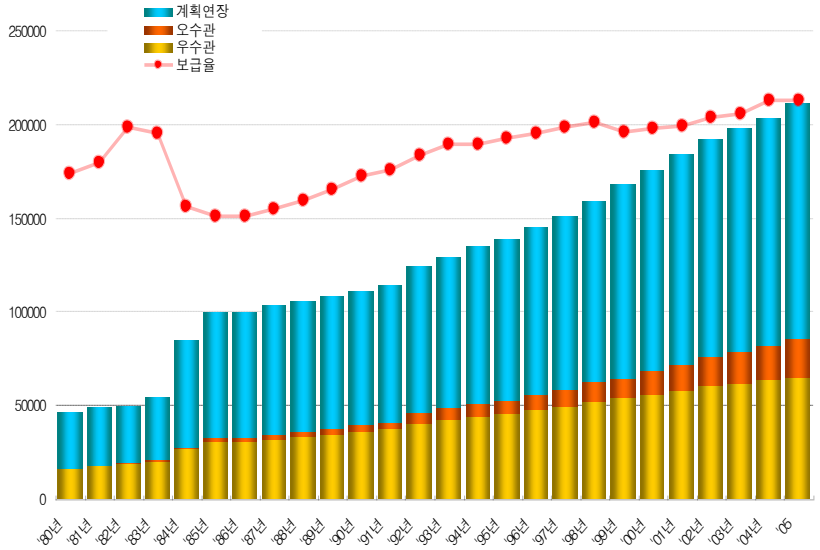
- Historical events and investment trend
  - related acts from 1963
  - investment boosted after 1980s



POTWs First, Sewer Next

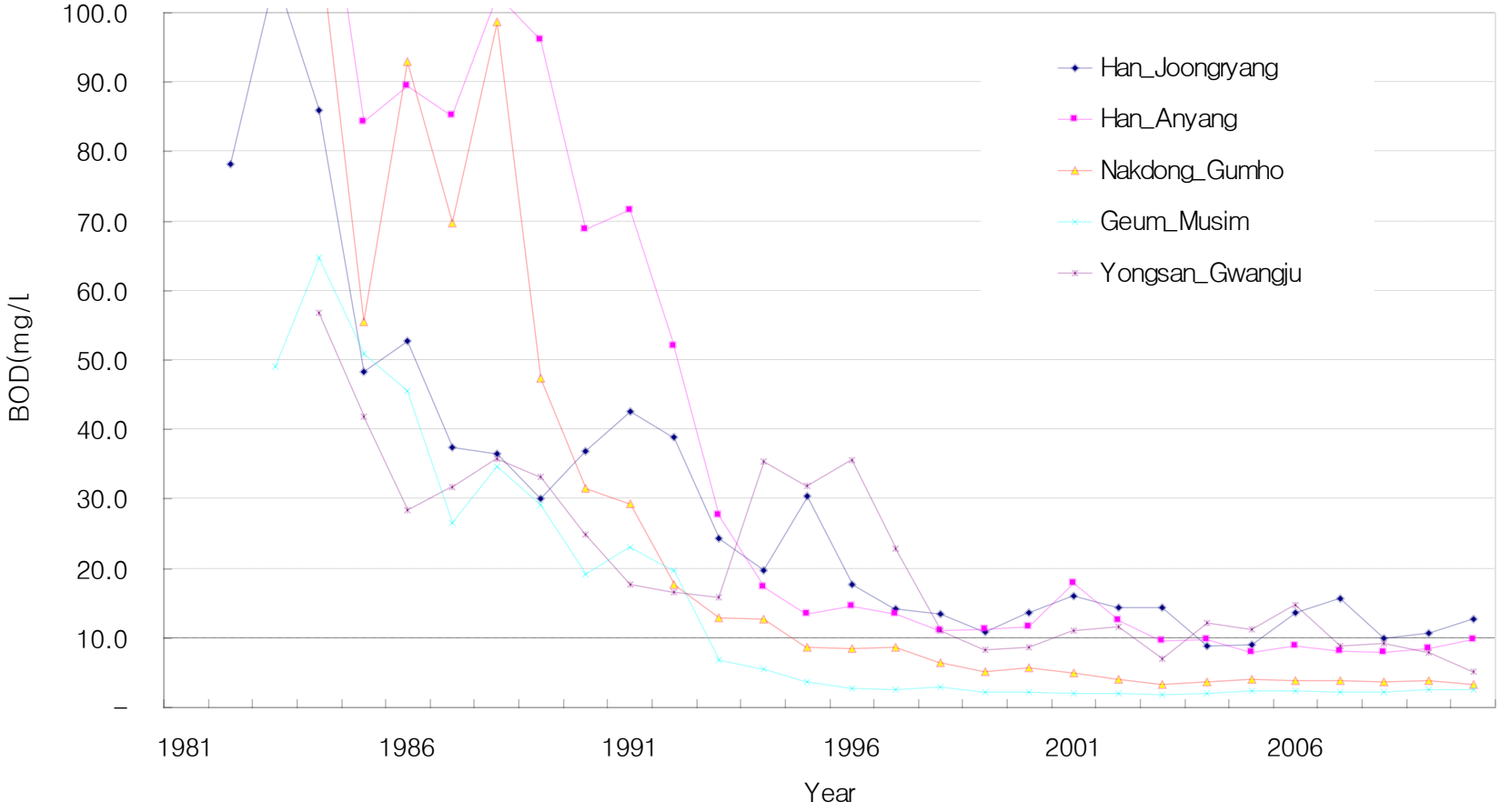
- Dramatic increase of sewerage service ratio
  - 3.6%(1977) → 40%(1992) → 84% (2005) → 89% (2010) → 93% (2015)
- Historically slow (insufficient) investment for sewer
  - [Install/Plan] 63%(1992) → 68%(2005) → 81%(2017)
  - [2005, 2007] Combined 56% → 31%, Separated 44% → 69%





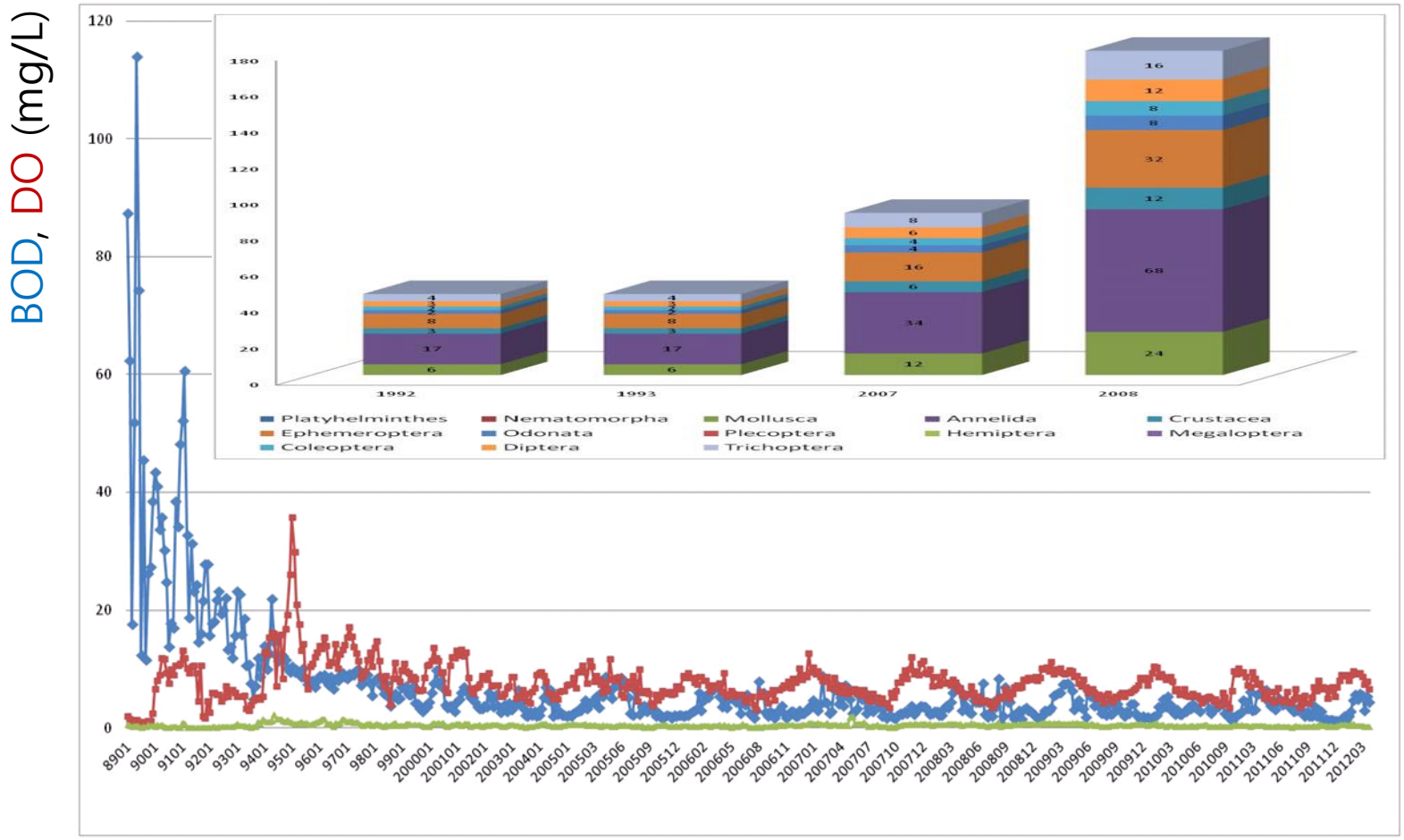
Water Quality of Urban Streams

- Water quality of urban stream was improved remarkably
- This has been changed people like to walk along the urban stream and now want the recovery of aquatic ecosystem
- How clean is clean?



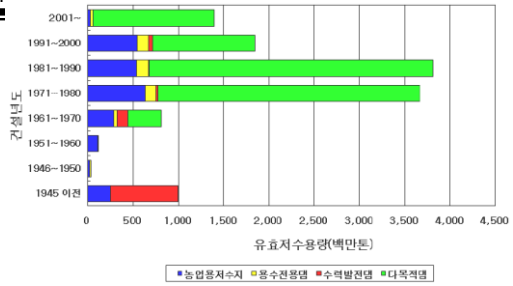
Restoration of Water Environment by Env. Water Infra

- The restoration of water quality and aquatic ecosystem in Keumho river.



Value Added Restoration of Urban Stream

Infrastructure Assets for Water Services

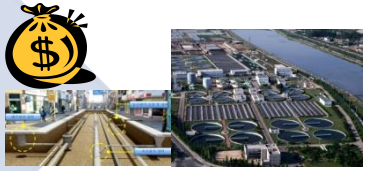


River and Stream
- Natural River
- Levee
- Drainage

Storage Structure
- Dam
- Barrage
- Reservoir

Water Supply
- Intake
- Water Treatment
- Pipe
- Well

Drainage and Treatment
- Sewer
- Wastewater Treatment



3,838 rivers
29,868 km length
5,600 drainage facilities

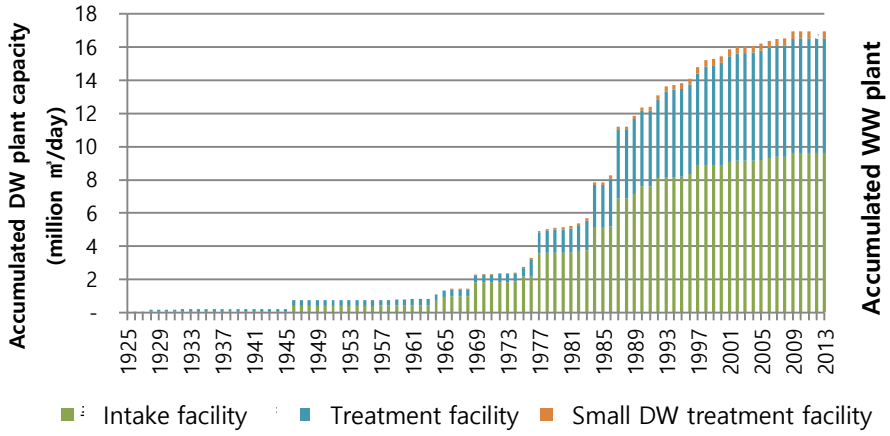
20 multi-purpose dams
54 water-supply dams
12 electricity dams
13 major barrages
17,427 agricultural reservoirs [2014]

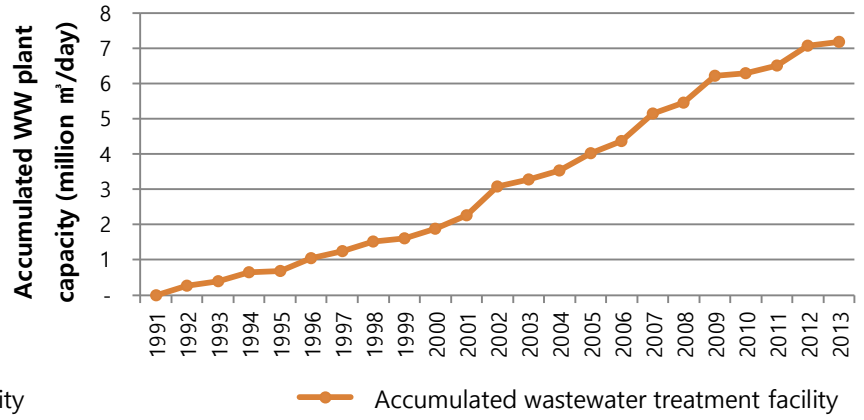
470 intake facilities [2016]
483 water treatment plants [2016]
1,998 distribution reservoirs [2016]
203,859km distribution pipe [2016]
70,289 agriculture water facilities [2016]
33,852 weir (5,251 fishways) [2016]
23,968 well [2016]

143,167km sewer [2016]
5,012 pumping stations [2016]
649 (+3,314) POTWs [2016]
194 NTPs [2016]
105 LMTPs [2017]
2,879,345 Individual STPs [2016]
198 IWTPs [2017]
54,823 IWWPs [2017]

Saturation of the Supply of Water Infra

- Sewerage: Service ratio increase - 92.8% (2015), 8.3% (1980, flushing toilet 33%)
- Drinking water supply: DW service ratio - 98.8% (2015), 55% (1980)
- Water storage facilities: Until 2020, only 1.8% deficit under past maximum drought condition. This means the possibility of water shortage from water infra is very low.
- River facilities: River bank plan 78.9%, river levee maintenance 54.5%, the property damage is increased but human injury is decreased.



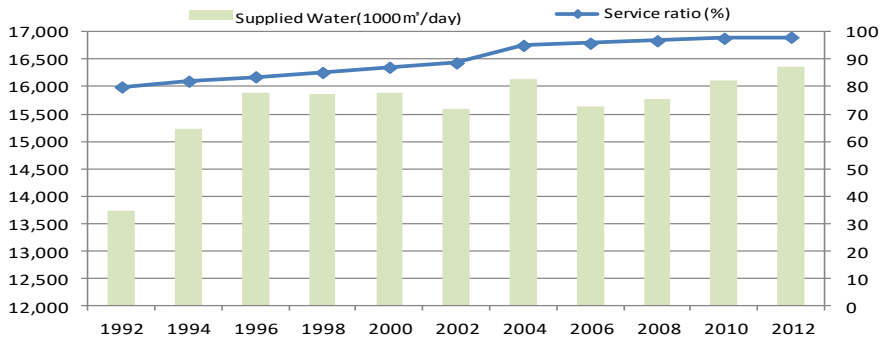


Service Expansion is Successful, But Not Equitable

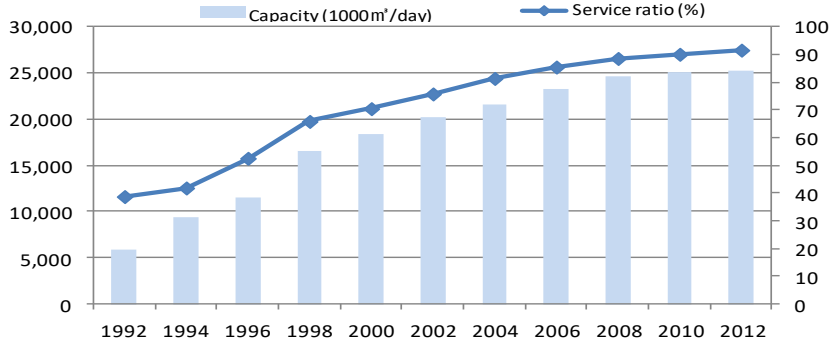
In Quantity

Nationally, DW service 98.8% and sewerage service 92.8% means success of expansion (*regional imbalance exists)

▪ Drinking Water Supply



▪ Sewerage Service



In Quality

Regional service difference exists (ratio, capacity, price, cost)

▪ Drinking Water Supply

City	Served Population (1000)	Service ratio (%)	Liter per capita per day (LPCD)	Total Supply (1000㎥/yr)	Price (KWON/㎥)	General price (KWON/㎥)	Realization of cost (%)
S	10,443	100.0	302	1,177,116	564.6	630.1	89.5
D	1,538	99.9	332	191,143	513.4	563.7	91.1
K	1,455	93.8	464	231,898	750.0	1,377.3	54.5

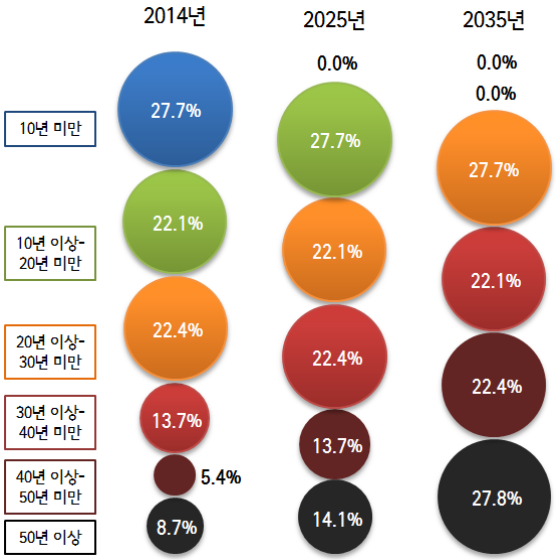
▪ Sewerage Service

City	Served Population (1000)	Service ratio (%)	Sewer coverage (%)	Sewer connected (%)	Price (KWON/㎥)	General price (KWON/㎥)	Realization of cost (%)
S	10,442	100.0	100.0	100.0	369.6	706.5	52.3
D	1,499	97.4	97.4	92.3	379.4	459.0	82.7
K	1,305	84.1	68.8	57.9	227.0	1,339.3	16.9

Current Sewerage Policy – Water Environment

- Improve the effects of sewerage service to people
  - Prevent and improve the safety related to sewerage service
  - Decrease the odor complaints from sewer
  - How to handle the use of disposer in sewer system
- Advanced sewerage management
  - Enhance the role of sewerage treatment to improve ambient water quality
  - Facilitate the use of treated effluents from sewerage treatment plants
  - Reduce and recover energy from sewerage sludge

After Construction, We Need O&M and Renewal of Infra

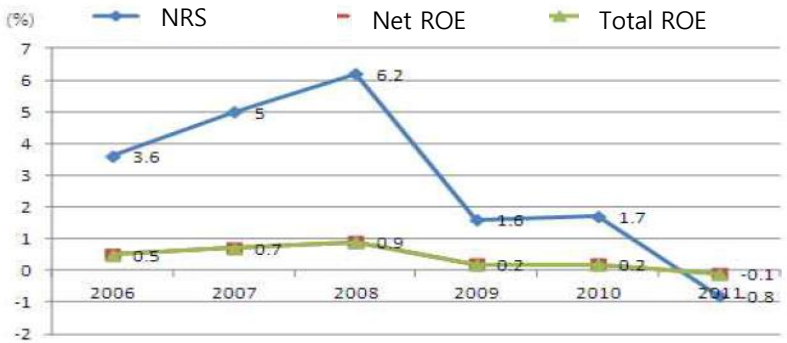


[Aged Rate Outlook (%)]

- Infra aging 27% → 72.3%('35년)
- Lowe price could not compensate O&M costs

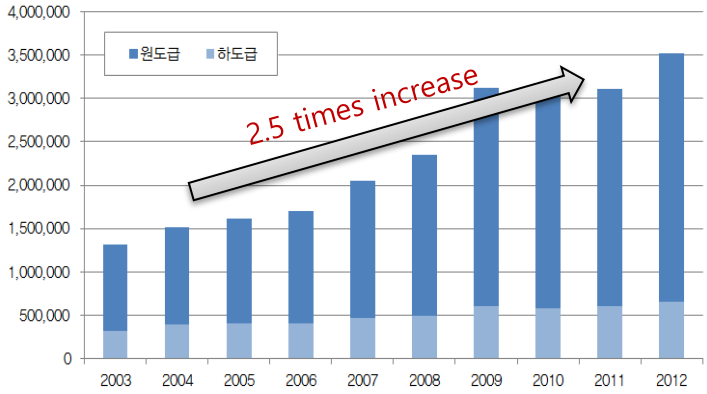
  (price for O&M : DW 80%, sewerage 40%)
- O&M costs are increasing, do not reflect renewal

  O&M/Construction : 14.6% (developed country 40%)



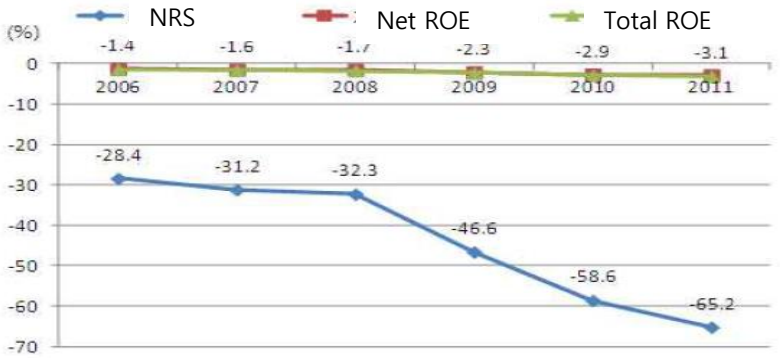
[DW net profit margin, data from Moon(2013)]

(million KWON)



[Facility O&M Business Market]

Data from O&M association



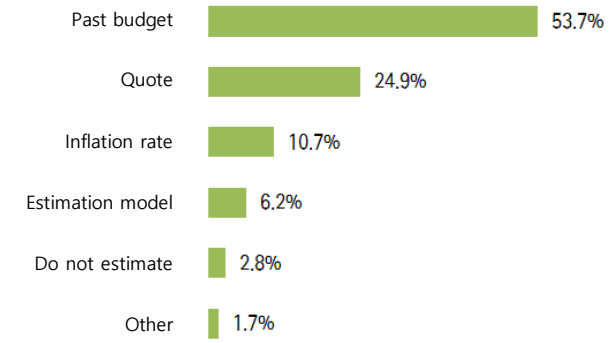
[Sewerage net profit margin, data from Moon(2013)]

Insufficient Preparation to the Era of Ownership

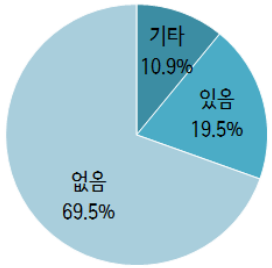
- Do not have systematic O&M process because of the lack of ownership
  - Most of the public utilities prepare O&M budget in reactive response.
  - It is difficult to prepare a time-intensive replacement due to aging facilities.

- Survey of local government utility manager for O&M of water infra (KEI, 2014)

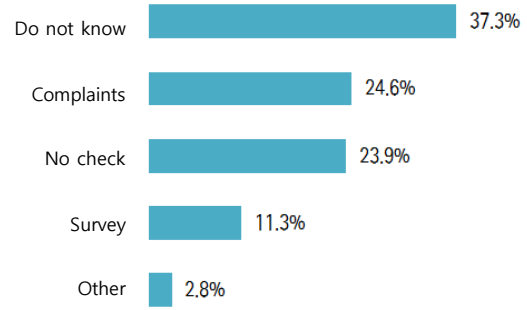
• How to estimate O&M budget?



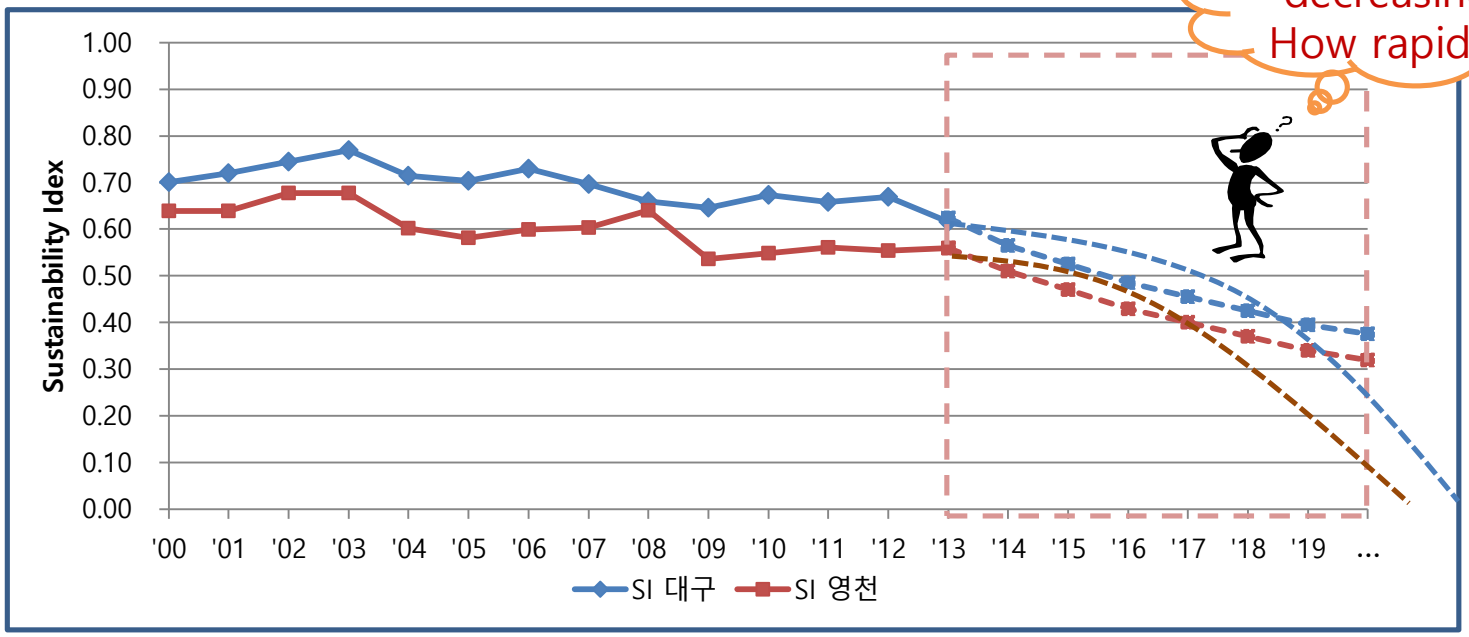
• Is there priority of O&M?

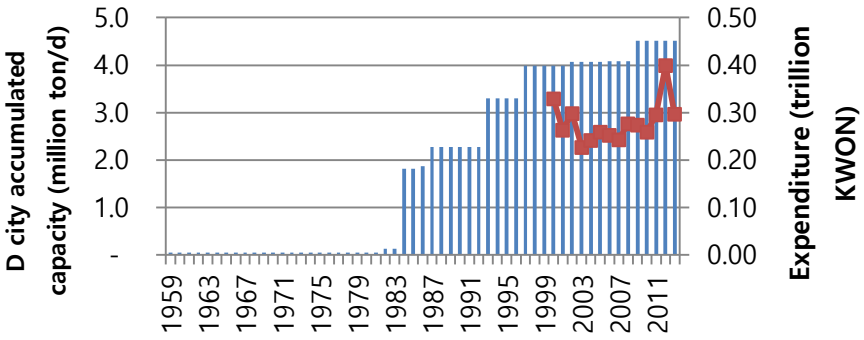


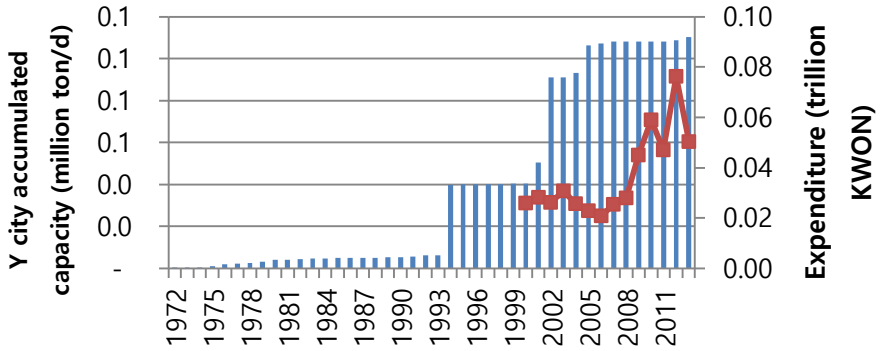
• Do you check Infra replacement / repair effect?



Decrease of Water Service Sustainability







- In case of D city and Y city, the sustainability of water service has been slowly decreased.
- After the completion of water infra until 2000, the sustainability of water service will be decreased rapidly mainly caused by current funding structure.

Low Price Undervalued the Importance of Water

- Low price of water by intended public price regulation resulted undervalued awareness for water services.
- Survey of critical infrastructure for water utility managers (KEI, 2014)

[Price of Public Utilities, 2012]		
	Utility	Spending (times)
1. Telecom	Telecommunication	145,374원 (10.1)
3. Energy	Fuel	67,700원 (4.7)
2. Transport	Transportation	56,477원 (3.9)
3. Energy	Electricity	51,068원 (3.5)
4. Water	Water	14,451원 (1.0)

Low Tariffs Weaken Water Industry

River and Stream
- Natural River
- Levee
- Drainage

23 B by river use

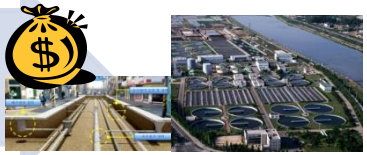
Storage Structure
- Dam
- Barrage
- Reservoir

810 B by Dam release

Water Supply
- Intake
- Water Treatment
- Pipe
- Well

3,286 B by water service [4,125]
946 B by K-water water service
889 B by WMF
7 B by groundwater

Drainage and Treatment
- Sewer
- Wastewater Treatment



1,487 by sewerage service [4,149]

Water income based on current charge	: 7,448 billion KWON
Water income based on [cost realization]	: 10,949 billion KWON
In case of full cost pricing?	: 3#,### billion KWON?
Governmental expenditure	: 14,580 billion KWON?
Water industry statistics	: 12,360 billion KWON?

Agricultural Water
- **Agricultural water user charges(estimated): 794 B KWON**
- **Total national paddy area income: 6,202 B KWON**

Ref. from various statistics, reports, articles

Institutional Change from Supply to Service and Ownership

- Legislation
  - Water Supply Act, Sewerage Act
  - Water supply master plan, sewerage master plan
- Decision Mechanism of Water Price
  - Decouple the price decision process from political situation
- Introduction of Asset Management Program
  - Transparent funding schedule by asset management program
  - Long-term funding plan to secure financial soundness
- Education for the Management of Water Service
- Reform the Water Utilities for Sustainable Water Service


Sustainable Water Service
for the Co-existence of Human & Nature